Thomas Edward Ferguson

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E-mail: tef2108@columbia.edu

BIO:

Thomas Ferguson received his undergraduate degrees in Physics and Astronomy from Vassar College in 2007. He joined Columbia University's Earth and Environmental Engineering graduate program in September 2008. His research has focused on the development of distributed energy conversion technology for biomass that produces fuel cell-ready hydrogen coupled with carbon capture. In May 2010, he completed his Master's degree, and he is continuing his research in his current program as a Ph.D. student.

SYNOPSIS:

Due to the issues of environmental sustainability associated with anthropogenic carbon emission and energy security, there is strong interest to develop a new generation of clean energy conversion technologies that utilize domestic resources. This project explores a method in which biomass is reacted with a hydroxide to produce hydrogen, a clean-burning fuel that can be used to produce power via a fuel cell, while simultaneously capturing carbon as a solid, avoiding re-emission of CO_2.

S Energy

Carbon Negative Hydrogen Production from Biomass

OBJECTIVE(S)/RESEARCH QUESTION(S)

Due to the issues of environmental sustainability associated with anthropogenic carbon emission and energy security, there is strong interest to develop a new generation of clean energy conversion technologies that utilize domestic resources. This project explores a method in which biomass is reacted with a hydroxide to produce hydrogen, a clean-burning fuel that can be used to produce power via a fuel cell, while simultaneously capturing carbon as a solid, avoiding re-emission of CO_2.

APPROACH

My Master's work demonstrated the viability of this process, known as alkaline hydrothermal treatment. My Ph.D. research will continue to explore important scientific and engineering questions. First, a variety of hydroxides such as calcium hydroxide and magnesium hydroxide will be thermodynamically and kinetically evaluated for the proposed alkaline hydrothermal treatment of biomass, starting with the model biomass compounds glucose and cellulose. Next, iron-based nanocatalysts will be incorporated in order to improve the reaction rate. Once the studies with the model compounds are completed, the developed hydrogen production system will be evaluated on heterogeneous biomass such as green algae. Finally, both environmental and economic analyses will be performed. Particularly, a detailed life cycle analysis will determine the carbon footprint of the proposed biomass refining technology.

EXPECTED RESULTS

The aforementioned experimental studies will contribute to the development of a distributed energy conversion system based on biomass. The demonstrated reaction conditions for this process of low temperature and atmospheric pressure will allow for simple reactor design, and the high purity of the hydrogen stream produced eliminates purification reactors, allowing for compact design. Kinetically, it is expected that the weaker alkaline earth hydroxides will not perform as well as the stronger alkali hydroxides during hydrogen production. However, the weaker alkaline earth hydroxides have the advantage of a lower energy requirement for their hydroxide regeneration. Alternatively, magnesium hydroxide, an alkaline earth hydroxide, would for magnesium carbonate via the proposed process, a material ready for carbon sequestration. Heterogeneous biomass feedstocks will likely require additional pre-processing as well as the identification of other gaseous and solid products. Catalysts are expected to further enhance hydrogen conversion. Finally, as the proposed scheme captures carbon, it is expected that the carbon footprint will be smaller when compared to the traditional hydrogen-from-biomass production processes of fast pyrolysis and gasification.

POTENTIAL TO FURTHER ENVIRONMENTAL/HUMAN HEALTH PROTECTION

By reducing our dependence on the burning of fossil fuels to obtain energy, the proposed research stands to further protect both the environment and human health. Curtailment in fossil fuel utilization would result in the mitigation of particulate matter, fine particles, volatile organic compounds, and sulfur compounds, emissions that the EPA cites as detrimental to air quality. Also, the development of the proposed distributed energy conversion system would reduce greenhouse gas emission, in particular carbon dioxide, while providing sustainable energy.

Keywords: *biomass, hydrogen, alkaline hydrothermal treatment, carbon capture and storage*